ADAPTING TO A CHANGING CLIMATE: CASE STUDY

CARBON TRADING ON A HILL COUNTRY FARM
Modelling the potential economic impact

THE MCRAE TRUST FARM

- A steep hill country sheep and cattle farm some 18kms West of Wairoa in northern Hawkes Bay.
- Approximately 614 hectares (492 hectares effective) and carries some 5500 stock units.
- Bequeathed to the people of New Zealand by Miss May McRae in 1975.
- A charitable Trust administers the farm activities and a Trust board attends to addressing the Trust Deed.
- The Hawkes Bay Regional Council (HBRC) has had a long involvement with the McRae Trust with many of the Council's sustainable farm management initiatives conducted on Trust land.
- There are small plantings of a number of tree species established to demonstrate their growth potential and effect on soil conservation.
- Species include radiata pine, eucalypts, cypresses, poplars, alders, acacias and some oak.

THE STUDY

- This study outlines the economic assessment made on a range of forestry options for a hill country trust farm
- The evaluation looked at the economic returns and land stabilisation that could be gained from a number of land-use options – planting different species for the purpose of carbon, timber or both, contrasted against sheep and beef farming.
- The outcomes will be of interest to any land owner looking at the economics of forestry in light of a proposed Emissions Trading Scheme in New Zealand.
- The study also highlights some important information about species selection, management regimes and the impact of forestry on hill country erosion.

The advent of some form of carbon trading scheme in New Zealand promises to substantially improve the economic viability of plantation trees as a form of land use.

Much of the hill country on the East Coast of the North Island of New Zealand is prone to erosion because of the combination of sedimentary mudstone soils, occasional heavy rain events and steepness of the topography. This makes pastoral farming of sheep and cattle challenging.

In November 2007 the Hawkes Bay Regional Council (HBRC) initiated a project to investigate the effect that new carbon sequestration policies might have on the economics of land use in hill country.

The project involved Crown Research Institute Scion and forestry consultants Hardwood Management Ltd in a joint case study to investigate different tree crop land use options on the McRae Trust farm.

This study was supported by Envirolink funding provided under the Foundation for Research Science and Technology.

CASE STUDY DESIGN

Five different crop options for carbon farming and land stabilisation were considered and estimates made of productivity, carbon sequestered, and soil holding capacity.

All crops were modelled over a total of 60 years in either two, 30-year rotations or a single rotation. Sheep and beef farming was also compared against the other options.

For the exotic species only, different management regimes were modelled including whether the plantation was to be thinned or "plant and leave", different numbers of stems per hectare and different end-uses – contrasting whether the plantation would be used for timber or carbon only, or both.

ECONOMIC ANALYSIS

Each option was analysed using a discounted cash flow approach with local costs and prices. Key variables were examined in a sensitivity analysis and compared with farming returns using land expectation value (LEV) and internal rate of return (IRR) where possible.

For each option costs, yields and log prices were entered into the Hardwood Management Ltd's land evaluation model to produce cash flows, and estimates of LEV and, where possible, IRR.

DISCOUNT RATE

Discount rates are often used as indicators of risk and where government policy is a significant factor in the investment, higher rates can be expected to be used. Also species choice, markets and infrastructure (such as ports and processing plants) should be considered when choosing a discount rate.

In this analysis, a discount rate of 8 percent has been used.

LEV – LAND EXPECTATION VALUES

The productive value of the land at 8 percent discount rate. The LEV could be considered the maximum price a buyer should be willing to offer to purchase bare land in order to achieve a required rate of return in a forestry land use, assuming that the use continues in perpetuity.

IRR – INTERNAL RATE OF RETURN

The discount rate often used in capital budgeting that makes the net present value of all cash flows from a particular project equal to zero. Generally speaking, the higher a project's internal rate of return, the more desirable it is to undertake the project.

CARBON PRICE

All regime options and carbon sequestered was costed at $20 per tonne. A range of carbon prices from $10 to $30 per tonne CO_2 were tested in the economic models constructed. LEV was shown to be very sensitive to changes in carbon price, particularly for the faster growing trees.

While nobody knows what the carbon price might stabilise to over time, it is generally accepted that NZ$20 per tonne is a conservative figure to model future pricing on.

CARBON YIELD

All volume yields were modelled using appropriate growth models for timber and carbon yields.

LAND STABILISATION

Soil stabilisation was examined by modelling root biomass production.

SUMMARY OF RESULTS

This study shows that revenue for carbon credits could improve the LEV on the McRae Trust Farm from $1700 per hectare for pastoral farming to greater than $5000 per hectare for tree crops, while IRR

TABLE 1: OPTIONS

CROP	REGIME	THINNING	ROTATION (YRS)	TIMBER	CARBON
1.	Native Forest		60		√
2.	Manuka/Kanuka/Tauhinu		60		√
3.	Poplar 120 sph		2 x 30	√	√
3.	Poplar 260 sph		2 x 30	√	√
3.	Poplar 550 sph		2 x 30	√	√
4.	Radiata pine, pruned, 350 sph	√	2 x 30	√	
4.	Radiata pine, pruned, 350 sph	√	2 x 30	√	√
4.	Radiata pine, pruned, 450 sph	√	2 x 30	√	√
4.	Radiata pine 400 sph	√	2 x 30	√	√
4.	Radiata pine 750 sph		60		√
5.	Eucalypt 600 sph	√	2 x 30	√	√
5.	Eucalypt 450 sph	√	2 x 30	√	√
5.	Eucalypt 1000 sph		60		√
	Sheep and Beef Farming		60		

1995 plantations at McRae Trust Farm.

for typical forestry regimes could improve from 4.2 percent to 9.8 percent.

The economic analysis indicated exotic species that grow quickly, such as eucalypts and radiata pine, gave the best results and the "timber only" with no carbon returns pine regime, gave the poorest, as measured by LEV.

For the 30-year rotations, the pine timber and carbon volumes estimated were generally less than the eucalypt but greater than the poplar estimates – a function of both growth rate and wood density. The higher the density in a piece of wood, the more carbon it contains.

The costs and loss of biomass from thinning and pruning detracts from the overall tonnage of carbon sequestered and so LEV's are subsequently reduced for regimes that include these.

The trends can be summarised as:

- Faster, early growth rates coupled with high wood density produce more carbon and better economic returns.
- Higher stockings sequester more carbon which translate into better returns.
- Less intensive management reduces cost, which further contributes to better returns.

The results from this study are specific to the McRae Farm site and may change significantly with different soils, environments, and markets that encourage other species or regimes.

LAND EXPECTATION VALUE AND INTERNAL RATE OF RETURN

LEV indicates that for the top option in this case study, an investor could afford to buy the land for $7031 per hectare, plant successive crops of "unthinned eucalypt" in perpetuity and make 8 percent return.

By contrast, at the other end of the range where only timber is produced, the LEV is negative. At current timber prices, the 8 percent discount rate cannot be achieved and returns of 4 percent are likely.

Because of their rapid growth rate and higher wood density, eucalypts top the table with lower levels of management intensity proving the best. This is followed by radiata pine also with lower levels of management intensity proving the best; sheep and beef farming then follows, with poplar, shrub regeneration and radiata pine "timber only" the least profitable.

The option of sheep and beef farming falls behind a number of the pine and eucalypt timber and carbon options, but is more economic than poplar and native vegetation land use options.

Though present farming fortunes are poor for a number of reasons, the results suggest that overall cash flow for the land could be improved by consigning the poorer farmland on the property to carbon forestry.

IRR naturally follow the same trend as LEV, but could not be calculated for the sheep and beef, poplar, shrub regeneration and native options. For the better tree crop options IRR exceeds 15 percent and would appear to be an attractive investment at that level.

Key points

1. **Income from carbon credits derived from tree crops can provide an alternative income stream to land owners.**
2. **For hill country farmers this could be achieved by: converting part of the steeper, less productive part of hill country into trees; spreading risk; reducing dependency on fluctuating livestock revenues, and improving soil stability.**
3. **A recent study on a Hawkes Bay farm showed that revenue from carbon credits could improve land expectation values from $1700 per hectare for pastoral farming to greater than $5000 per hectare for tree crops, while rates of return for typical forestry regimes could improve from 4.2 percent to to 9.8 percent.**
4. **In this study, the economic analysis indicated exotic species that grow quickly, such as eucalypts and radiata pine, gave the best results.**
5. **If the choice of species planted is strategically linked to the land type then greater benefits could be achieved.**
6. **A whole farm estate plan is needed to better understand the feasibility of carbon farming with trees.**

CARBON SEQUESTRATION AND YIELD

Carbon accumulated in various tree species relates directly to their respective growth rates and density. Applying good species to site matching is critical.

Species that establish quickly and grow fast with moderately dense wood, such as eucalypts and pine are likely to be favoured for farm planting under the ETS.

Management regimes are likely to be less intensive with an emphasis on volume production per hectare and crops may be grown for longer periods than currently indicated for timber harvest. Generally, unthinned options sequester more carbon than thinned options and higher stockings of the same species sequester more carbon.

Annual carbon sequestration rates are similar to timber annual growth rates, where initial growth is rapid until competition between trees occurs and there is gradually decline in rate as tree size increases. The thinned options show a sharp decline in growth (and sequestration) following thinning, but then recover as remaining trees use up the available resources made available by the demise of the thinned trees.

Carbon is lost after a crop is felled, as seen in this case study in with the two crops harvested for timber at 30 and 60 years. Due to carbon build up in the soil and sequestration in the roots, the level remaining following felling at 30 years is still appreciable.

For the first few years following felling, carbon levels continues to decline with decomposition until the newly planted crop starts sequestering carbon at a greater rate than the level of decline. The final carbon level of the second crop is comparable to that of the first crop when it too is felled at age 30, 60 years into the regime.

TIMBER VALUES

The single "timber only" option did not perform as well as the options of growing pine for carbon only, or timber and carbon.

For "timber only", revenue is only earned in years 30 and 60, whereas for options with carbon trading, revenues start from when the tree is aged three. Added to this, there has been a drop in log prices over the past few years (particularly the differential between pruned and unpruned logs), making it harder to make good returns from timber only.

SOIL STABILISATION

The planting of trees on erosion prone hill country sites will provide direct soil stability benefits.

From a soil stabilisation perspective there is merit in capturing the site as quickly as possible while also capturing carbon credits quickly. Fast growth equates to better soil stability adding to improvement in water quality by reducing erosion and reducing the amount of water available for runoff.

The ability of trees to hold soil on slopes and thus perform an erosion prevention function depends on a number of factors:

- **SPECIES:** growth rate, depth of root penetration, tensile strength of roots.
- **SOIL CHARACTERISTICS:** clay content, underlaying bedrock, friability.
- **SITE:** slope steepness, rainfall pattern and intensity, land use.

Poplars are well known for their deep root system and their ability to grow from poles. This makes it much easier for the farmer to stabilise soils on slopes and not lose the grazing potential of the pasture by planting poplar poles and protecting the poplar stem with a plastic, expanding sleeve.

However, to become effective, calculations suggest that poplars require 14 tonnes of root biomass to hold soil on slopes. These root systems develop at different ages for different stockings of poplar plantings, the earliest being seven years when planted at 550 sph.

Root biomass is critical in soil stabilisation.

For pine the figures are 30 tonnes of root biomass per hectare and for initial stocking of greater than 750 sph, this occurs when the tree is around seven years. Pine has a shallower root system and lower tensile strength than poplar, hence the greater volume of root biomass required to reach the tree's holding capacity.

Tree regimes and species that optimise carbon credits are also likely to give greater soil stabilisation than traditional spaced poplar planting.

TREE SPECIES

The low tree stockings and lower wood density of the poplar compared to both pine and eucalypt make poplar a poor proposition for carbon and the lack of continuous wood supply and markets make it a doubtful candidate for timber production.

Both native scrub regeneration and native forest preservation are slow in growth and therefore showed least carbon sequestration ability. Their presence as a land use may be justified as enhancement and preservation of biodiversity.

Reverting scrub areas may also be left for reasons of erosion control, that is, more soil loss may occur from animal tracking or clearing and replanting activities than leaving the area fallow.

FOR MORE INFORMATION

- *The impact of carbon trading on the economics of hill country forestry in New Zealand*: G West, B Poole and K Molony.
- Barry Poole, Hardwood Management Ltd: Phone: 07 308 9029

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